

# Nesting Studies with HYCOM at NRL

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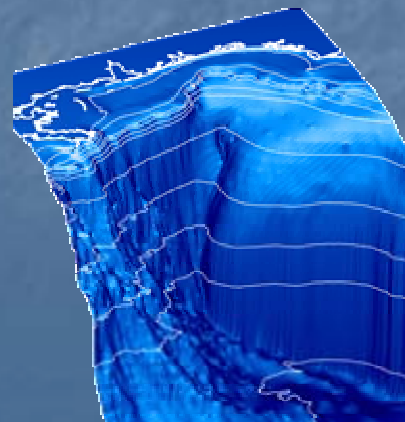
8<sup>th</sup> Hybrid Coordinate Ocean Model Workshop  
August 20, 2003  
NCEP, Camp Springs, MD.

Report Documentation Page			Form Approved OMB No. 0704-0188		
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1. REPORT DATE <b>AUG 2003</b>	2. REPORT TYPE		3. DATES COVERED <b>00-00-2003 to 00-00-2003</b>		
4. TITLE AND SUBTITLE <b>Nesting Studies with HYCOM at NRL</b>			5a. CONTRACT NUMBER		
			5b. GRANT NUMBER		
			5c. PROGRAM ELEMENT NUMBER		
6. AUTHOR(S)			5d. PROJECT NUMBER		
			5e. TASK NUMBER		
			5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Naval Research Laboratory,Stennis Space Center,MS,39529</b>			8. PERFORMING ORGANIZATION REPORT NUMBER		
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSOR/MONITOR'S ACRONYM(S)		
			11. SPONSOR/MONITOR'S REPORT NUMBER(S)		
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release; distribution unlimited</b>					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>Same as Report (SAR)</b>	18. NUMBER OF PAGES <b>21</b>	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			

To go with the HYCOM-based global ocean prediction system scheduled for transition to NAVOCEANO in FY06

### **We need accurate nesting of coastal models**

- Nesting to higher resolution coastal domains using HYCOM and/or NCOM
- Implies a vertical remapping from global HYCOM to the target vertical structure of the coastal domain
- The nesting scheme must accurately represent flow regimes with widely different dynamics and time scales (e.g. in shallow water, over the continental slope and in deep water, with all three present in many cases).



**Mississippi Bight**

# Current Status of Nesting

## HYCOM NESTING in HYCOM

- Currently off-line
- Boundary info comes from archive files
- Exact boundary condition for depth averaged component
- Relaxation in buffer zone for T,S,P,u,v
- Updating frequency limited by archive file frequency
- Don't need to know nested area in advance

### Off-line:

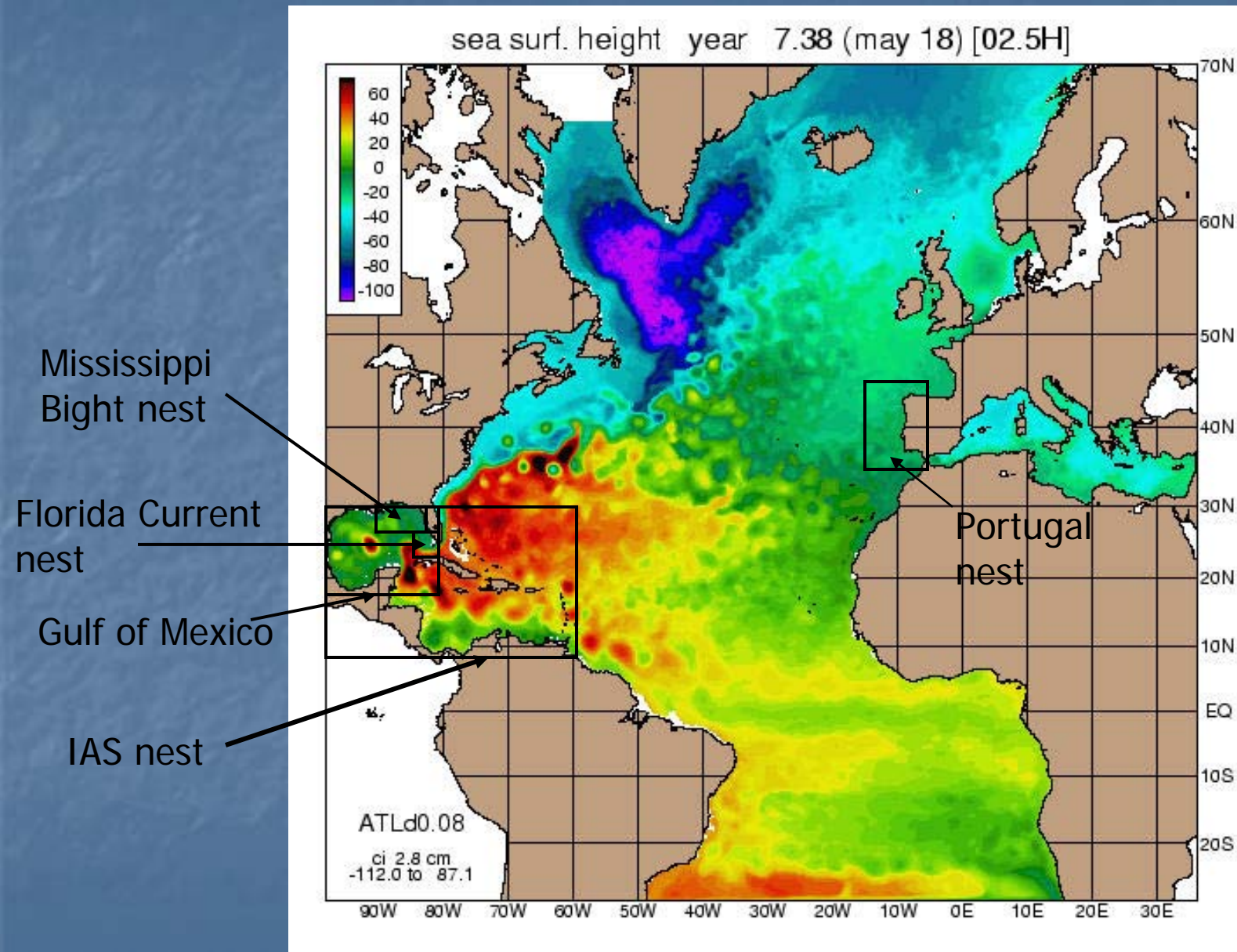
- Boundary information comes from archive files
- Updating frequency limited by archive file frequency
- Don't need to know nest area in advance

### On-line (not yet implemented):

- Local model runs simultaneously with regional/basin-scale model
- Coupled via a vertical remapper
- Need to know nested area in advance

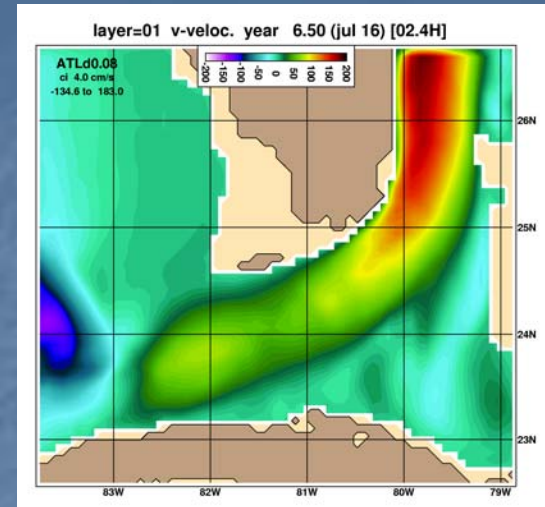
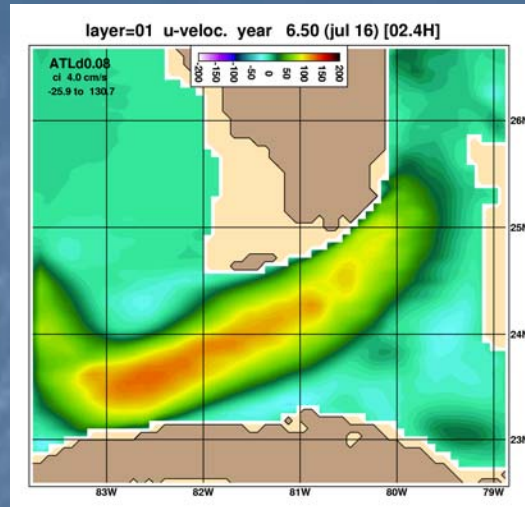
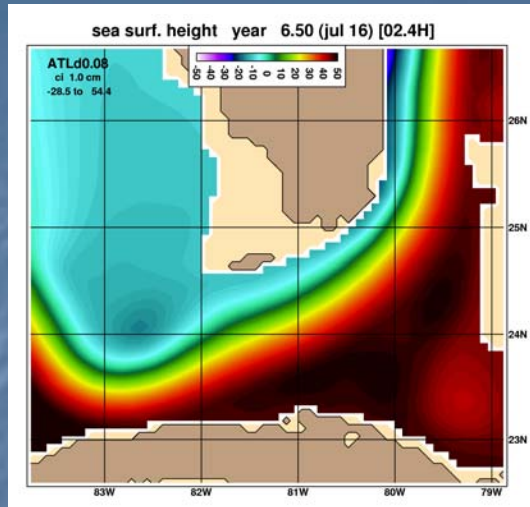


# 0.08° (1/12°) Atlantic HYCOM

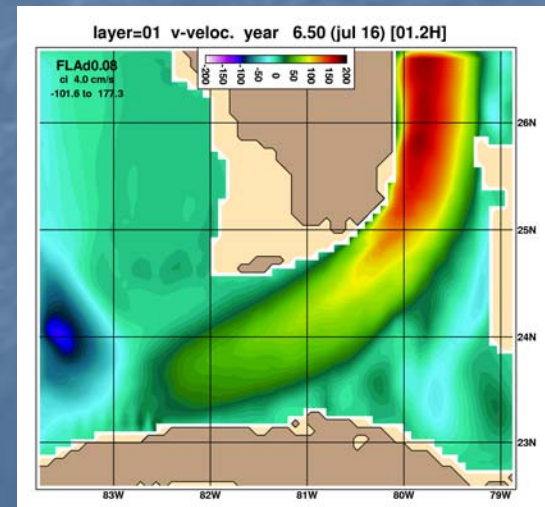
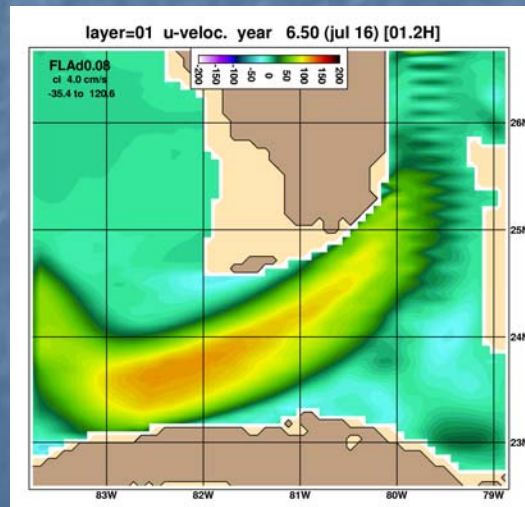
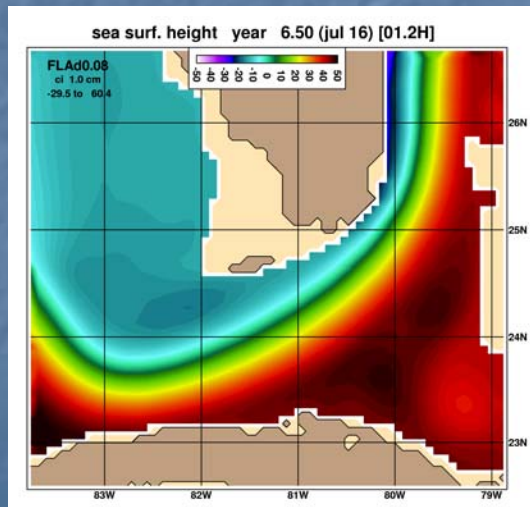


1/12° Pacific HYCOM also exists

# 0.08° Florida Current Nested Region



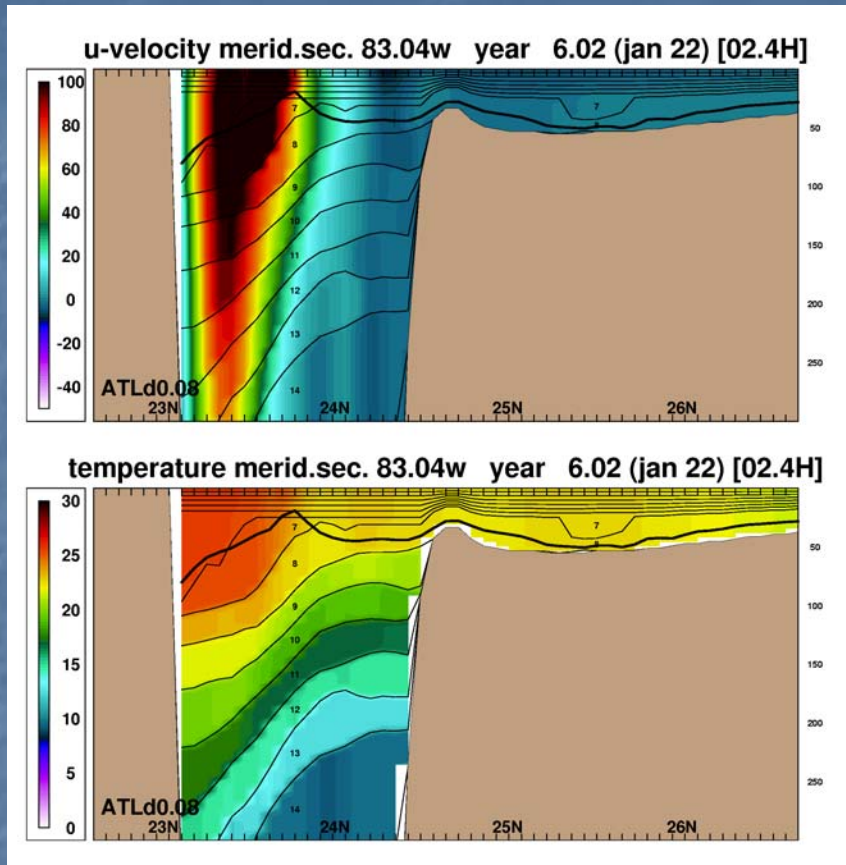
Original SSH, u,v after 180 days



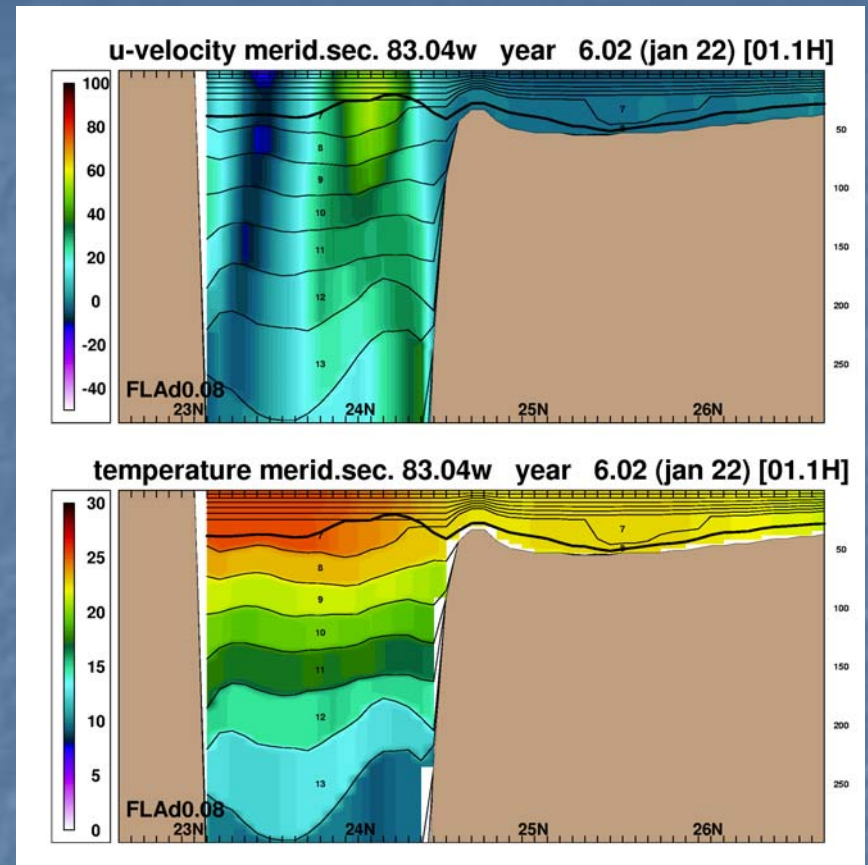
Nested SSH, u,v after 180 days (0.1-9 day e-folding; T-S-p,u,v relax)



# 0.08° Florida Current Nested Region

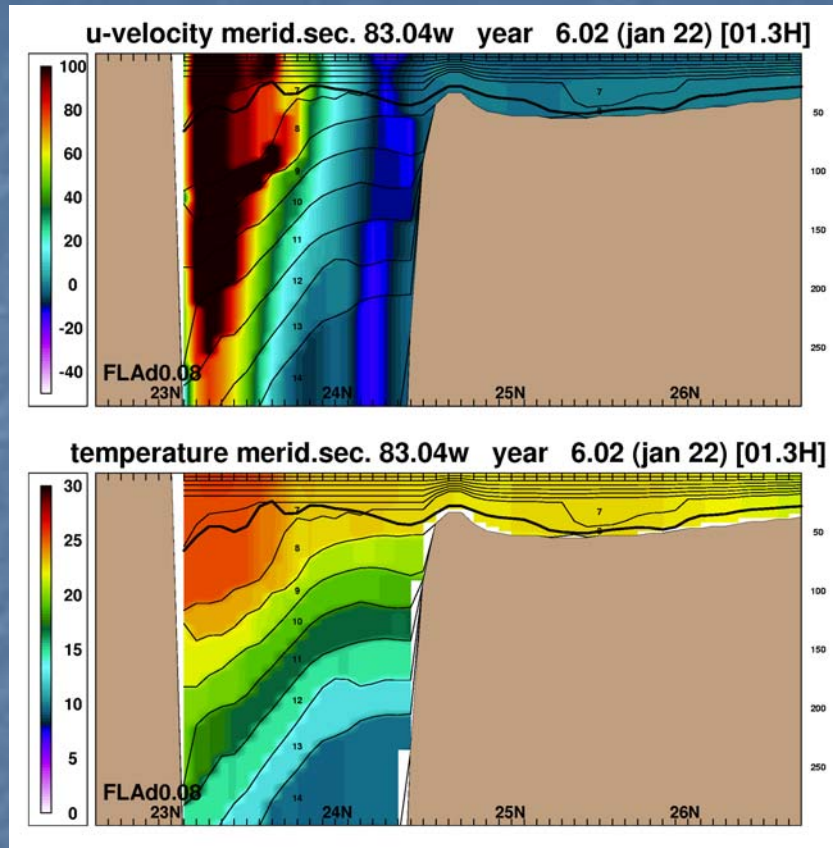


Original section after 6 days

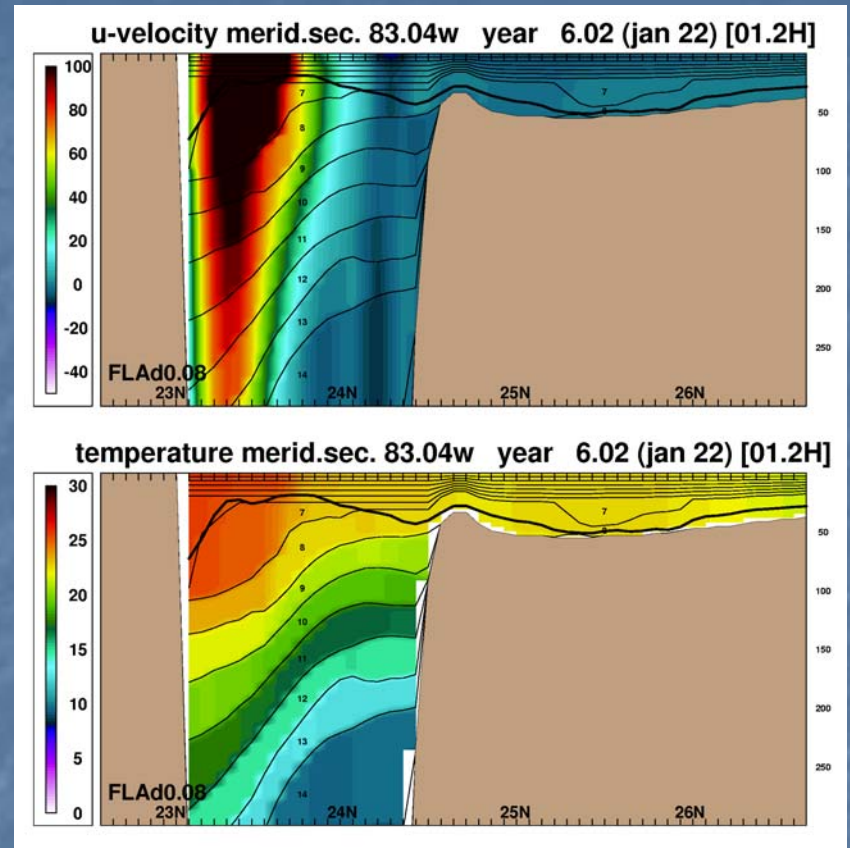


Nested section after 6 days:  
1-day e-folding T-S-p relax

# 0.08° Florida Current Nested Region



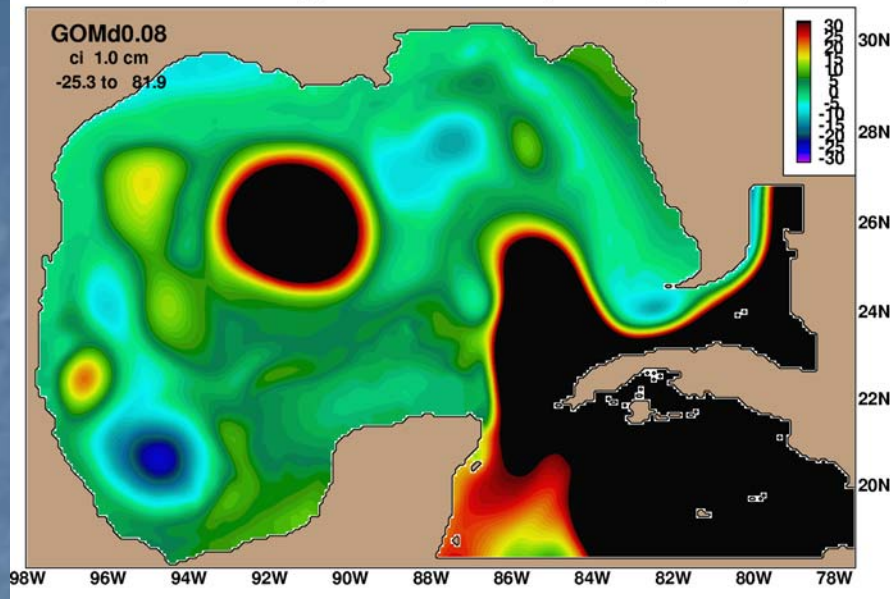
Nested section after 6 days:  
0.1-day e-folding T-S-p relax



Nested section after 6 days:  
0.1-day e-folding T-S-p-u-v relax



sea surf. height date: nov 02, 1999 [02.6H]

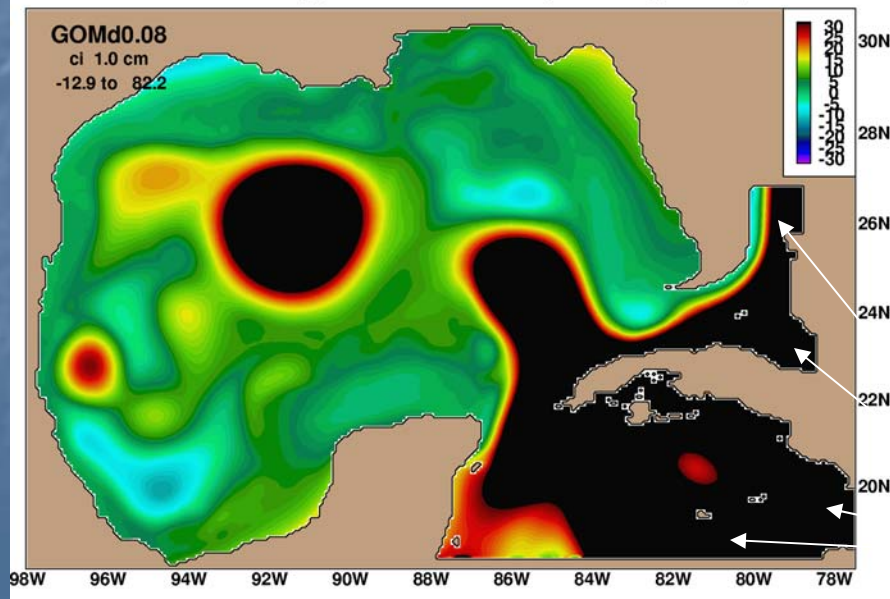


0.08° Gulf of Mexico nested  
inside of 0.08° North Atlantic

0.08° North Atlantic

3 months after restart  
Relaxation to T,S,p  
1-10 day e-folding time

sea surf. height date: nov 02, 1999 [01.2H]



0.08° Gulf of Mexico

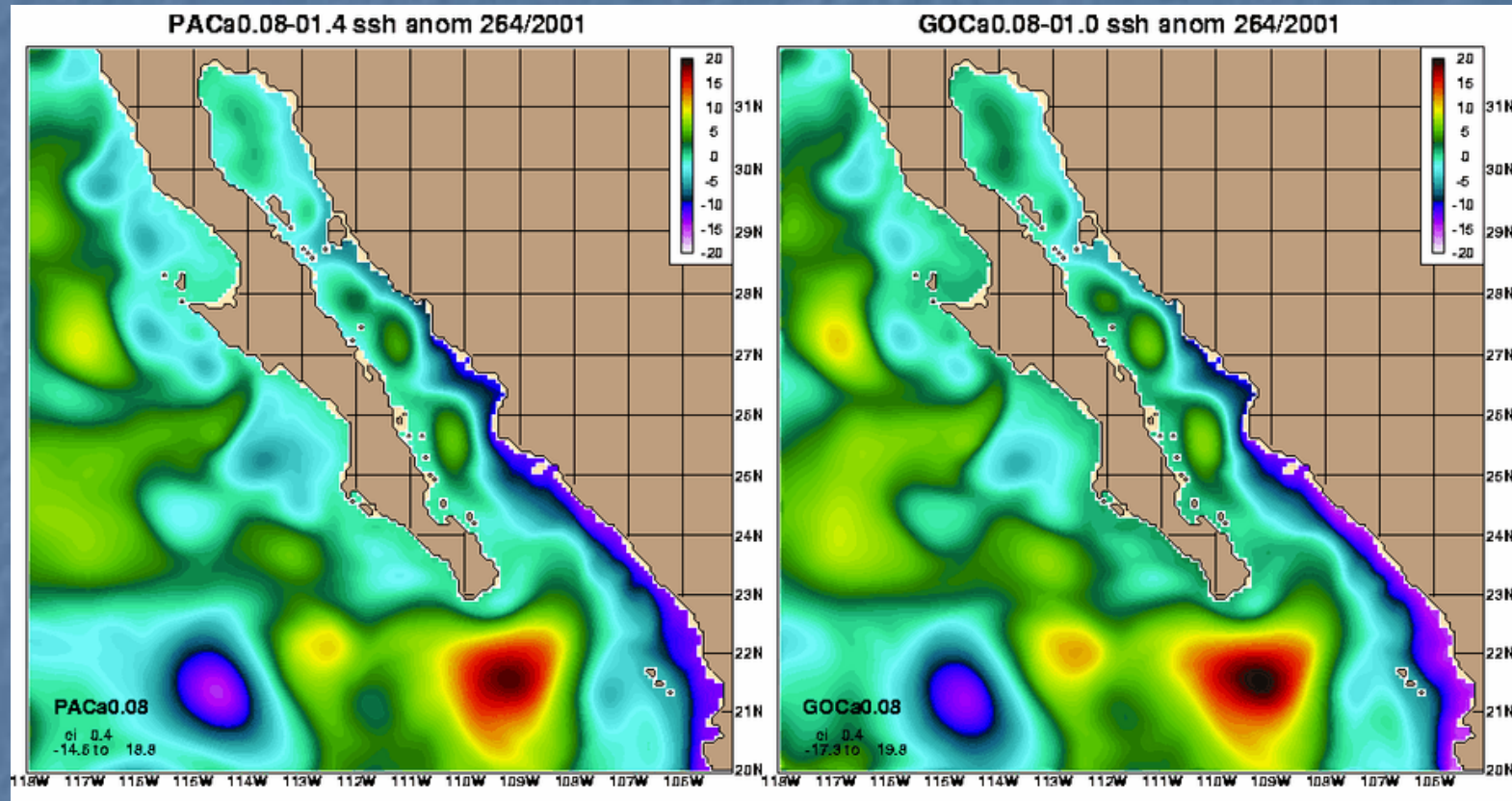
Plan to due 3x nest or ~2.7 km

Relaxation buffer zones

# Gulf of California Nesting

0.08° Pacific Ocean Model

0.08° Nested Gulf of California

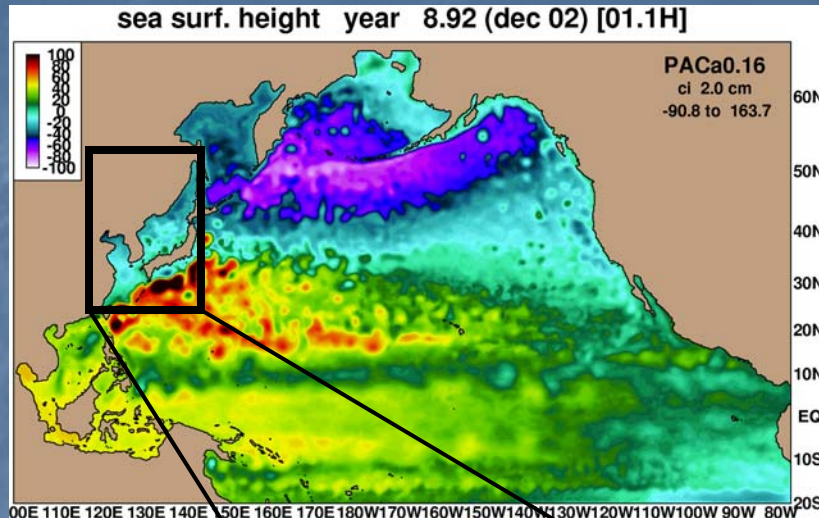


1-10 day e-folding time, relaxation to T,S,p,u,v

21 days after initialization

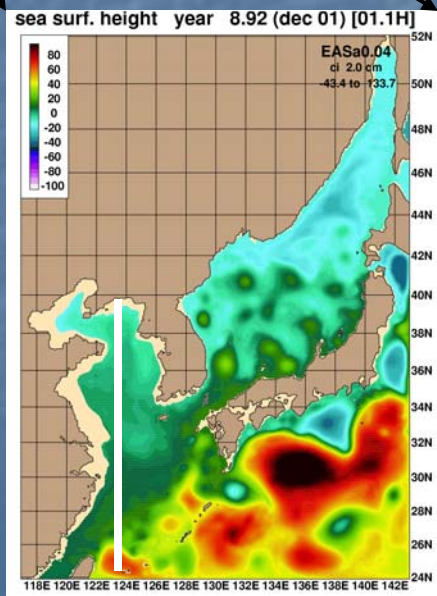
Courtesy: Joe Metzger

# 1/25° (3.5 km) East Asian Seas HYCOM Nested inside 1/6° North Pacific HYCOM



open boundary  
conditions from 1/6°  
North Pacific HYCOM

Nested model has same vertical  
structure as Pacific Ocean model  
(20 layers)



- Currently off-line
- Boundary info comes from archive files
- Exact boundary condition for depth averaged component
- Relaxation in buffer zone for T,S,P,u,v



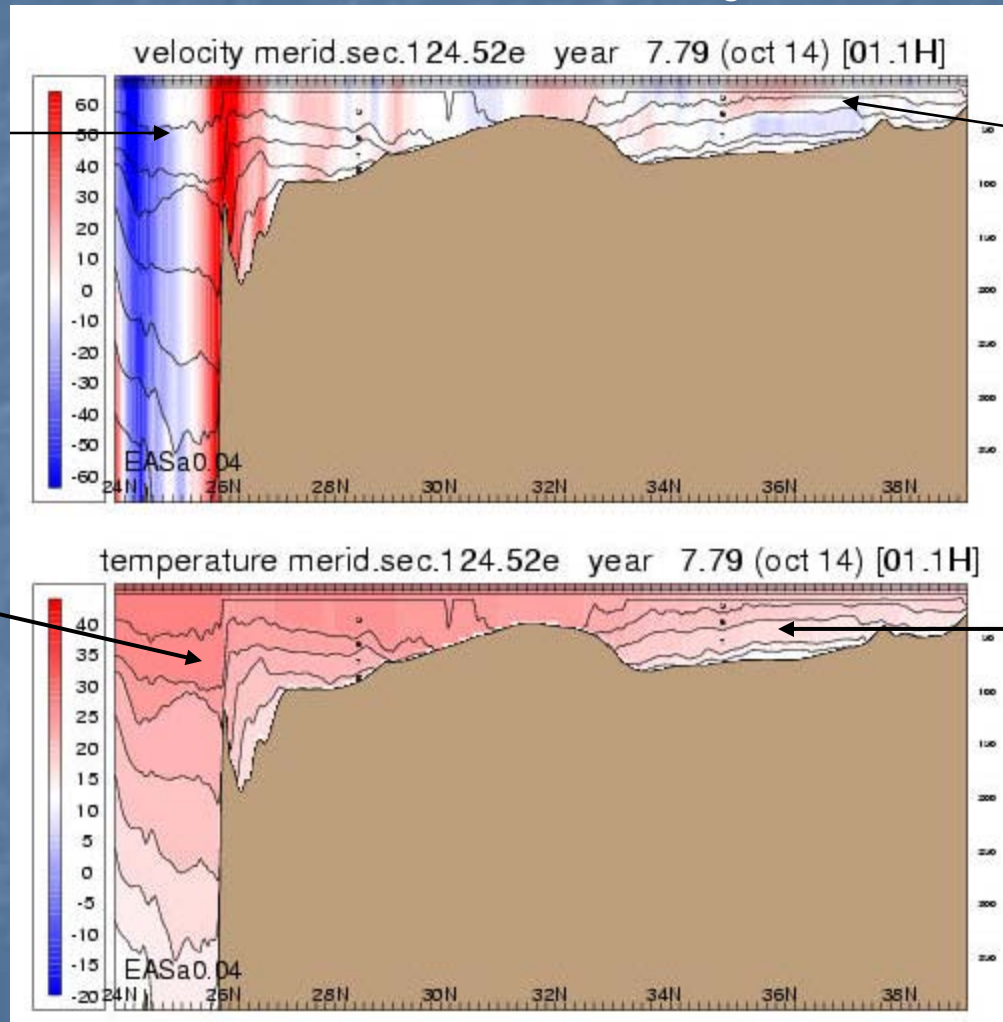
# 1/25° HYCOM East Asian Seas Model (nested inside 1/6° North Pacific Model)

North-south cross-section along 124.5°E

East China Sea

blue=westward flow  
red=eastward flow

Yellow Sea flow  
reversal with depth



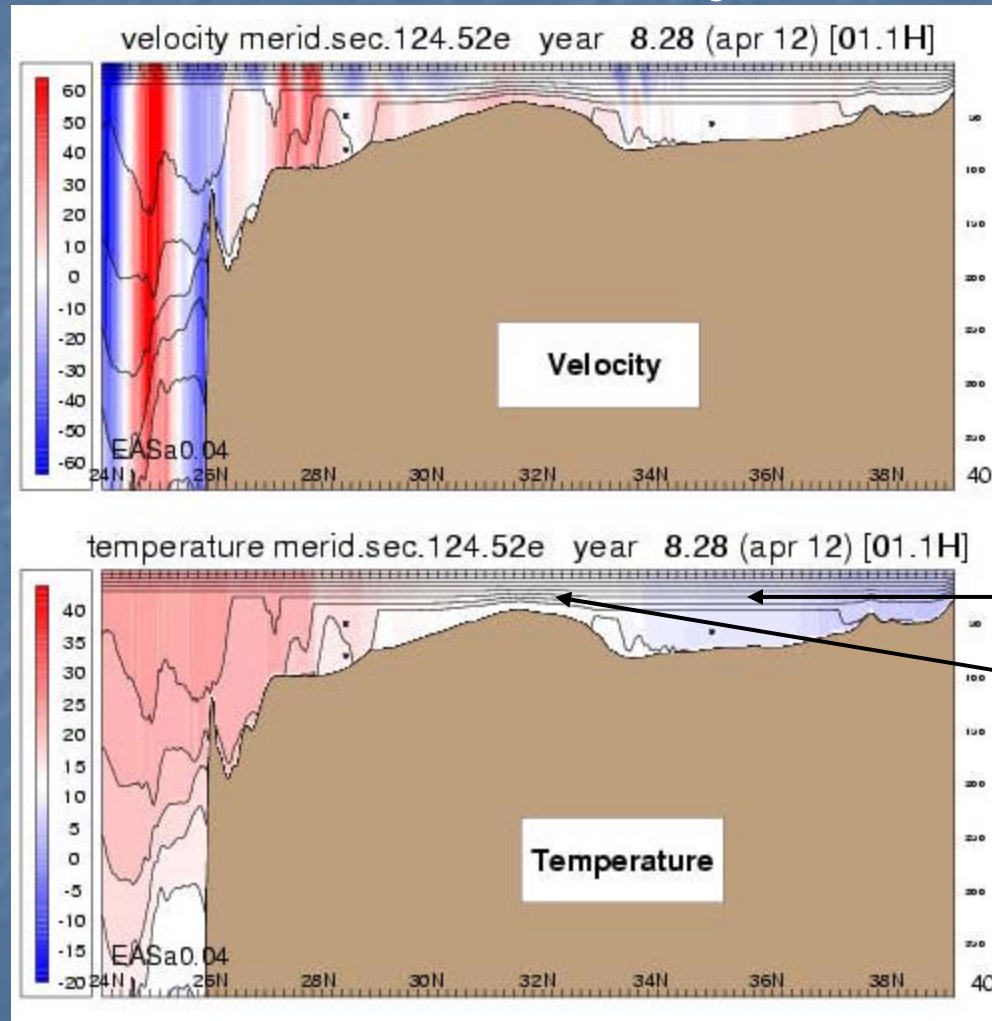
Isopycnals over  
shelf region

Snapshot on Oct. 14

# 1/25° HYCOM East Asian Seas Model (nested inside 1/6° North Pacific Model)

North-south cross-section along 124.5°E

red=eastward flow  
blue=westward flow



Snapshot on Apr. 12

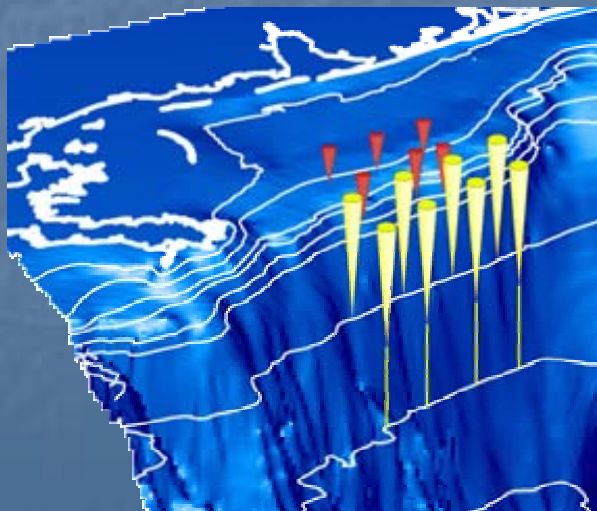


# Future Plans

## Slope to Shelf Energetics And Exchange Dynamics

(Jacobs, Teague, Hogan, Arnone)

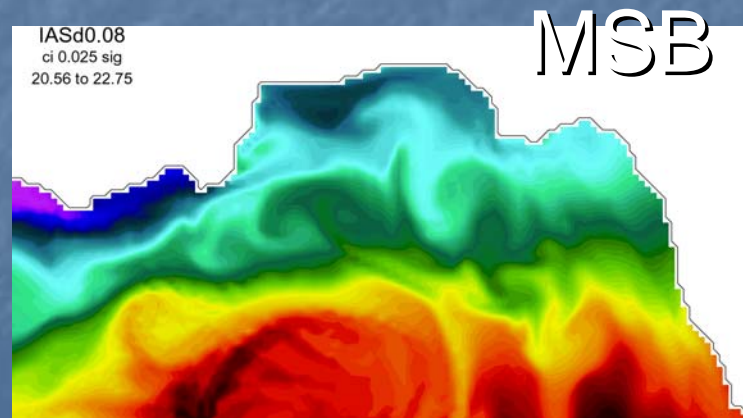
*Measuring and modeling of  
processes that affect cross-  
slope exchanges in the GoM*



## Coastal Ocean **CO-NESTS** Nesting Studies

(Hogan, Kindle, Wallcraft)

- *Develop HYCOM coastal capabilities*
- *Evaluate coastal HYCOM and NCOM*
- *Evaluate coupling and boundary conditions*



Mississippi Bight Domain



# NCOM

# HYCOM

## Navy Coastal Ocean Model

- Designed for coastal ocean Modeling
- Hybrid sigma-Z vertical coordinate (sigma is terrain-following)
- Transition between coordinates fixed (ideally at shelf break)
- Limited representation of topog. (full cells in z-level mode)
- ~ 3 times faster per layer than HYCOM
- Developed from POM by Paul Martin (NRL)

## Hybrid Coordinate Ocean Model

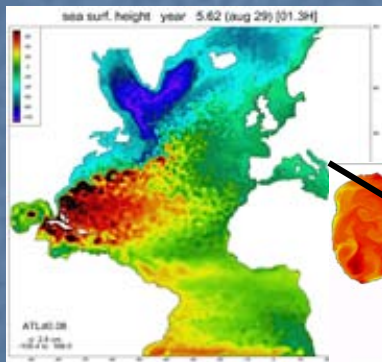
- Designed for deep water domains and accurate deep to shallow water transition
- Hybrid isopycnal-sigma-Z
- Dynamic in space and time
- More flexible design
- Don't need as many isopycnals as Z-levels in deep water
- Developed by NOPP HYCOM consortium

Can HYCOM do both global and coastal domains?

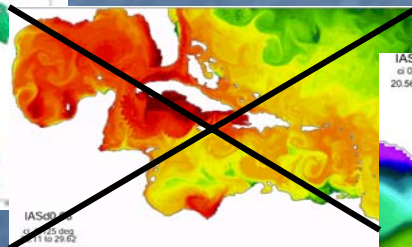
We will nest coastal HYCOM and NCOM within regional and/or global HYCOM with progressively finer horizontal and vertical resolution

- Sub-kilometer horizontal resolution is the goal
- Optimal vertical coordinate over shelf and shelf slope (isopycnals over the shelf when water is stratified?)
- Sensitivity to nesting ratios, number of nests, type of boundary condition
- Dynamical impact of increased horizontal and vertical resolution
- On-line nesting capability for multiple coastal nests

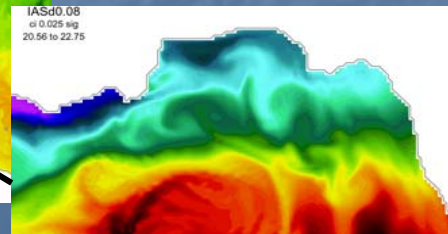
Run on massively parallel supercomputers



North Atlantic  
(NATL) Domain



Intra-Americas  
Sea (IAS)  
Domain



Mississippi  
Bight domain

Eliminate need for regional models by end of decade

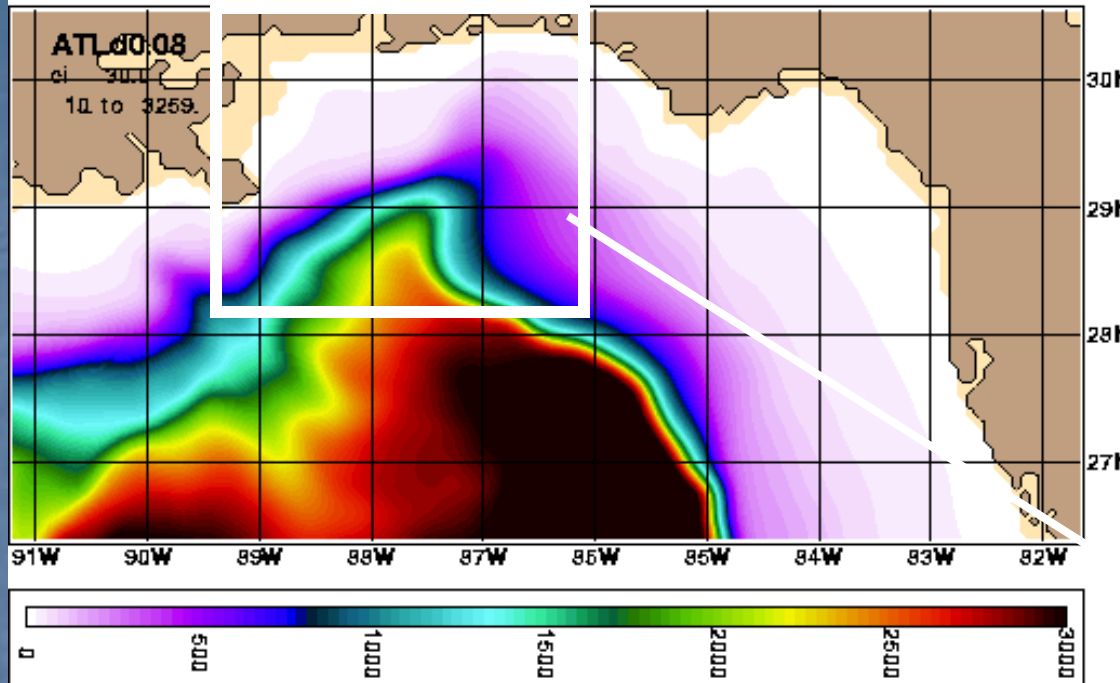
Run on Workstations or  
low-cost clusters

# Mississippi Bight

- Test cases are for the Mississippi Bight
  - Primary focus area for two NRL projects using NCOM and HYCOM (CO-NESTS) and HYCOM and ADCIRC (SEED)
- Large Mississippi Bight domain using HYCOM
  - Nested inside an Atlantic domain using HYCOM, both at 0.08 degree resolution
  - Using off-line, file-based, nesting
  - Makes the HYCOM domain practical (3 processors instead of 200+)
- Smaller Mississippi Bight domain using NCOM
  - Always has 40 fixed levels in the vertical
  - Nested inside HYCOM using archive files for boundary exchange
- Two test cases already performed as part of CHSSI project (Wallcraft)
  - 0.08 degree 40-level HYCOM, 0.08 degree 40-level NCOM
  - 0.08 degree 26-layer HYCOM, 0.08 degree 40-level NCOM

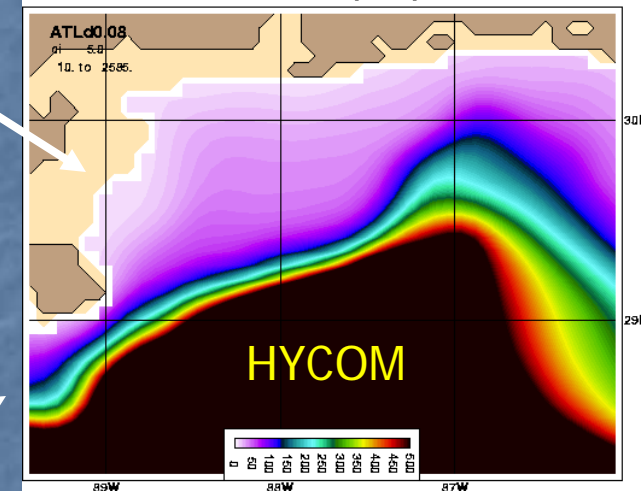


## HYCOM Bathymetry

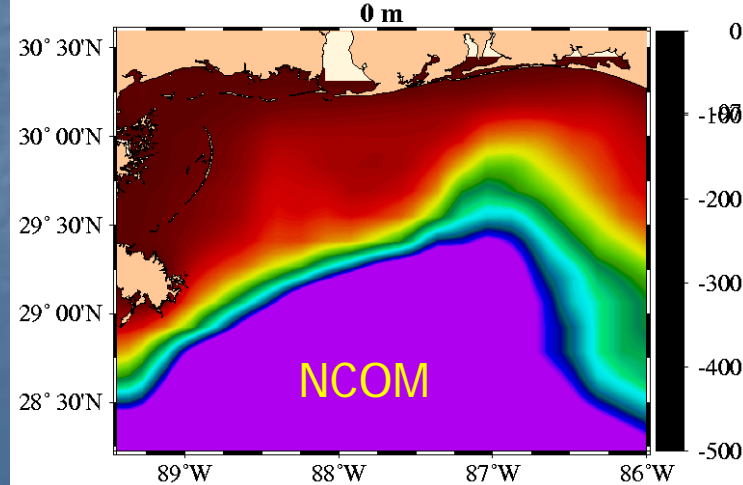


Initially a HYCOM subregion will be set up

## HYCOM Bathymetry

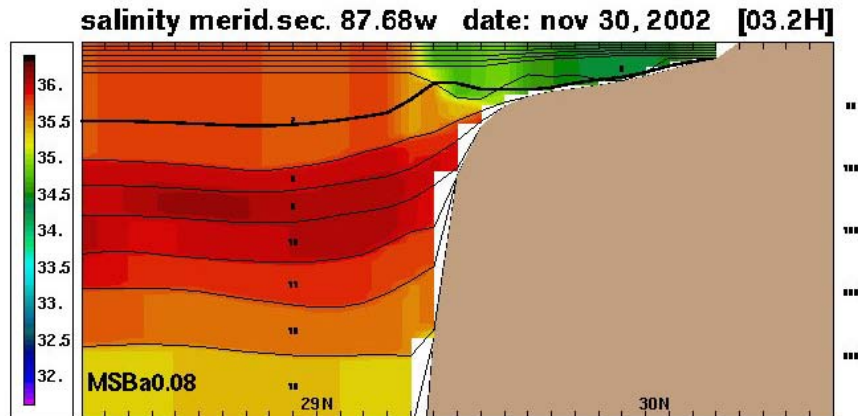
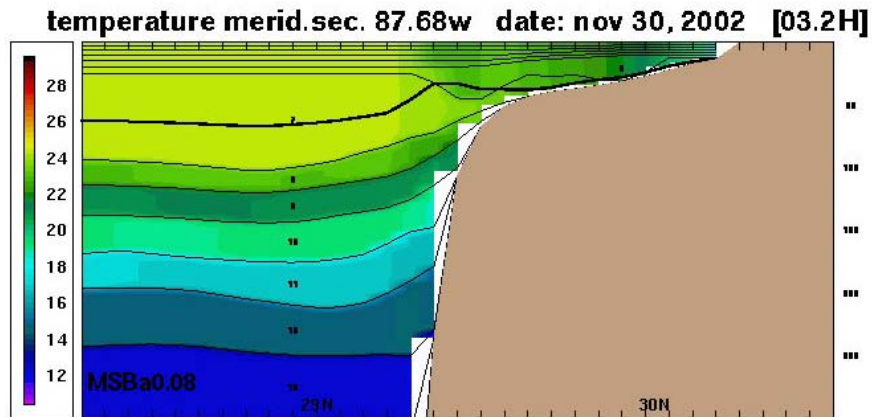


## Topography (m)

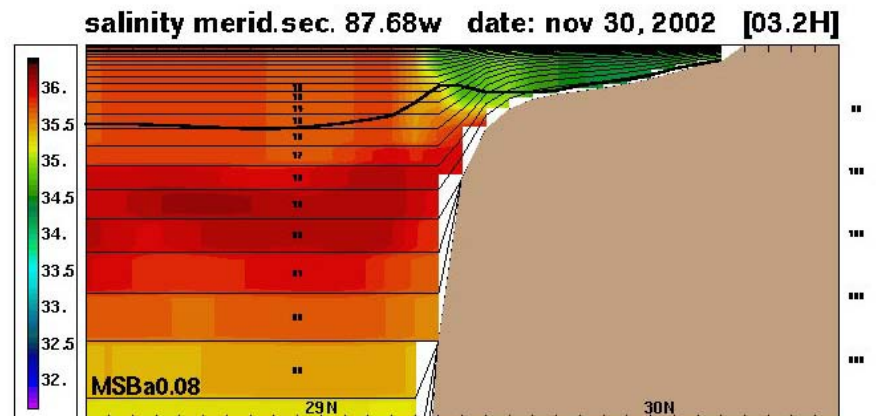
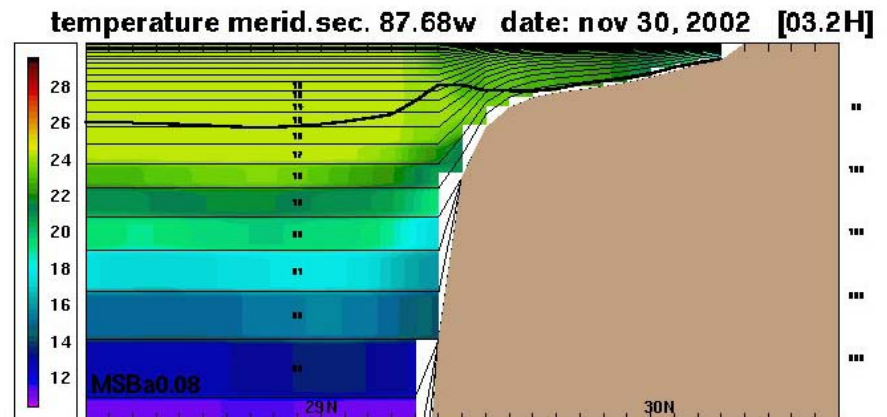


HYCOM and NCOM initial and subregions will match

## 26-layer HYCOM



## Remapped to 40 levels



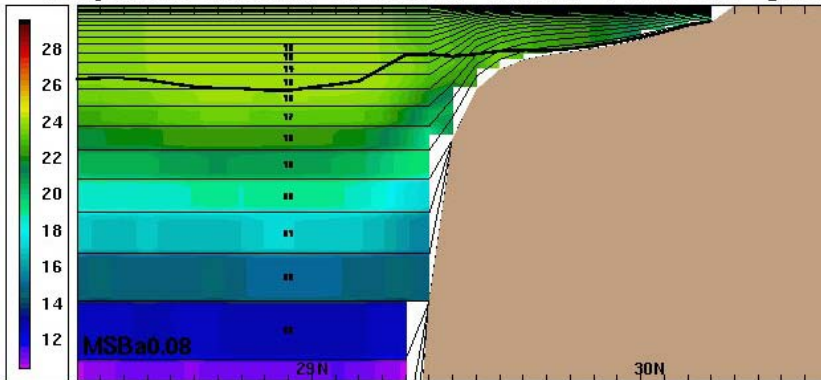
PLM remapping from 26 layer HYCOM to 40 level sigma-z

# Nest of 40 level HYCOM to 40 level NCOM

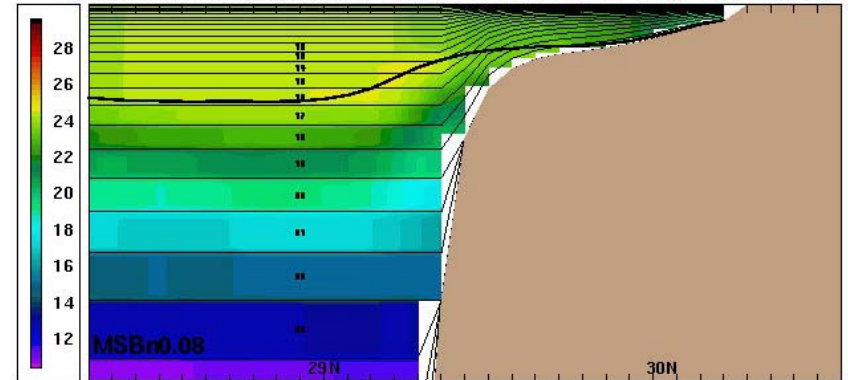
## 40-level HYCOM

## 40-level NCOM

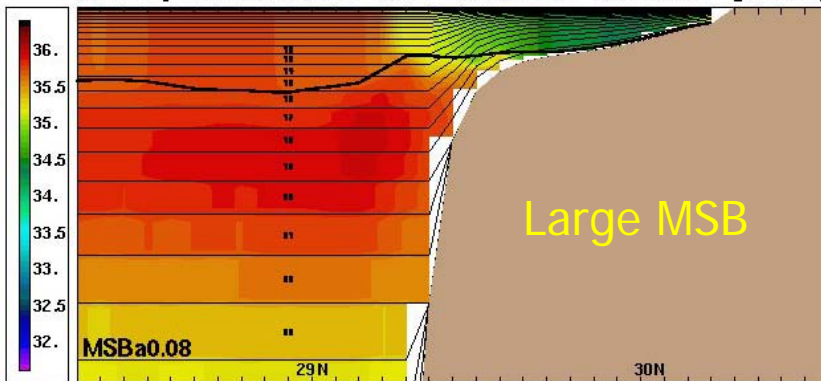
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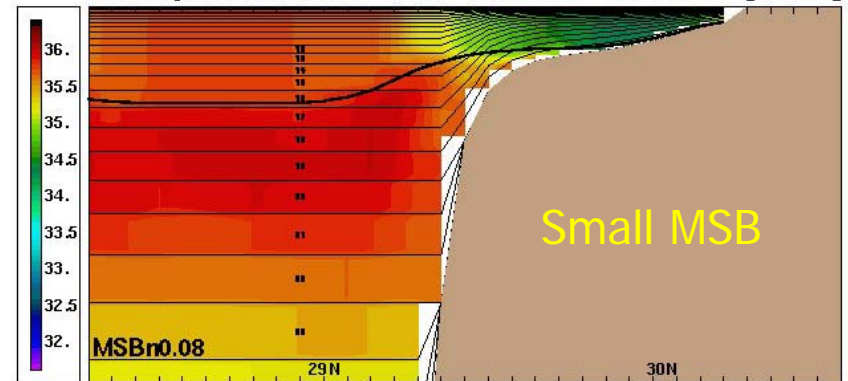
temperature merid.sec. 87.68w date: nov 30, 2002 [94.3H]



salinity merid.sec. 87.68w date: nov 30, 2002 [04.3H]



salinity merid.sec. 87.68w date: nov 30, 2002 [94.3H]



Large MSB

Small MSB

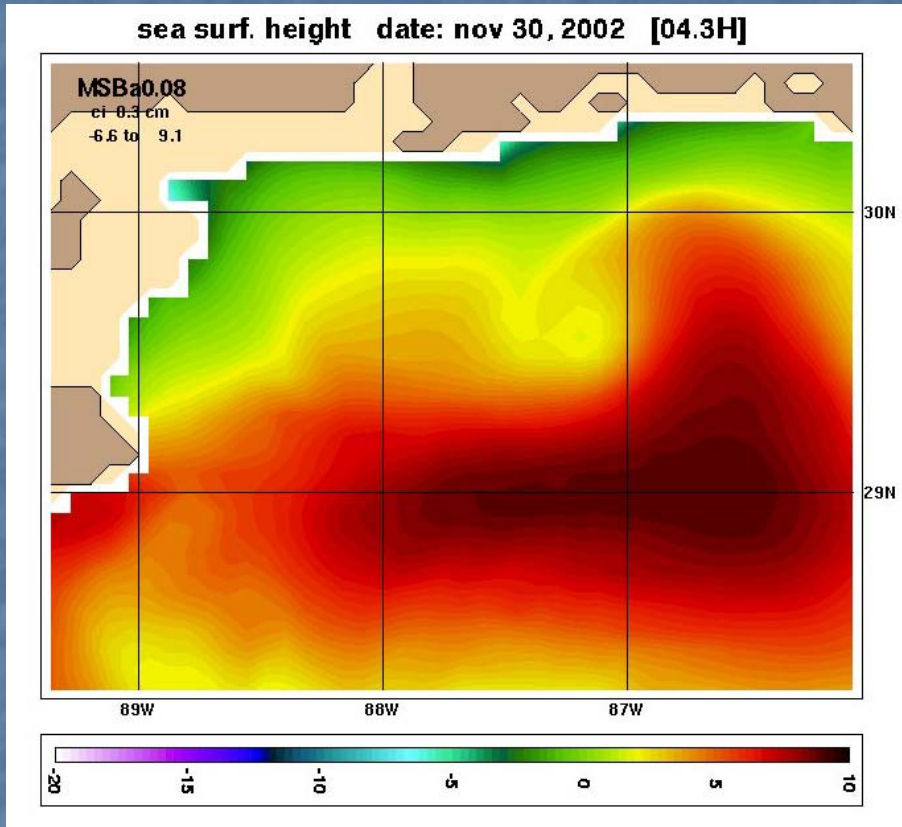
6 days after restart

Generalized vertical remapping is the goal



THE END

## SSH 40-level HYCOM



## SSH 40-level NCOM

